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(54) **CONJUGATED POLYMER AND SEMICONDUCTOR DEVICES INCLUDING THE SAME**(71) Applicant: **Iowa State University Research Foundation, Inc.**, Ames, IA (US)(72) Inventors: **Malika Jeffries-EL**, Ames, IA (US); **Jeremy J. Intermann**, Seattle, WA (US); **Brian C. Tlach**, Ames, IA (US)(73) Assignee: **Iowa State University Research Foundation, Inc.**, Ames, IA (US)

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H01L 51/50 (2006.01)(52) **U.S. Cl.**
CPC *H01L 51/0036* (2013.01); *H01L 51/0035* (2013.01); *H01L 51/5012* (2013.01); *Y02E 10/549* (2013.01)(58) **Field of Classification Search**
USPC 526/257; 548/148; 528/377, 380, 378
See application file for complete search history.(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP 10340786 A 12/1998
JP 2007238530 A 9/2007

OTHER PUBLICATIONS

Hellerich et al., Macromolecules 2012, 45, 6888-6897.*
Park et al., Journal of the Korean Physical Society, 2012, 60, 925-928.*
Hegedus, L. S. et al., "Synthesis of 2,B-Disubstituted 3,6-Diamino-1,4-benzoquinones", J. Org. Chem., 47, (1982), 2607-2613.
Kim, I. T. et al., "Synthesis, characterization, and properties of a new thiophene-benzobisthiazole copolymer", Synthetic Metals, 156, (2006), 38-41.

Klare, J. E. et al., "Cruciform pi-systems for molecular electronics applications", J Am Chem Soc., 125(20), (May 21, 2003), 6030-1.
Lim, J., et al., "Benzobisoxazole Cruciforms: Heterocyclic Fluorophores with Spatially Separated Frontier Molecular Orbitals", J. Org. Chem., 76, (2011), 10207-10219.
Osowska, K., et al., "Supramolecular organization of extended benzobisoxazole cruciforms", Chem Commun (Camb), 46(24), (Jun. 28, 2010), 4276-8.
Tlach, B. C. et al., "Tuning the optical and electronic properties of 4,8-disubstituted benzobisoxazoles via alkyne substitution", J Org Chem., 76(21), (Nov. 4, 2011), 8670-81.

* cited by examiner

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The present invention relates to conjugated polymers. In various embodiments, the present invention provides a conjugated polymer including a repeating unit including a benzene ring conjugated with the polymer backbone, wherein the benzene ring is fused to two 5-membered rings, wherein each fused 5-membered ring includes N and at least one of O and S. In various embodiments, the present invention provides semiconductor devices including the polymer, and methods of making the polymer.

21 Claims, 47 Drawing Sheets